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Keith E. Gregory  
*U.S. Meat Animal Research Center*

Sherrill E. Echternkamp  
*U.S. Meat Animal Research Center*

L. Dale Van Vleck  
*U.S. Meat Animal Research Center*

Larry V. Cundiff  
*U.S. Meat Animal Research Center, Larry.Cundiff@ars.usda.gov*

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# Twinning in Cattle

Keith E. Gregory, Sherrill E. Echternkamp, L. Dale Van Vleck, and Larry V. Cundiff<sup>1</sup>

## Introduction

Rate of reproduction has a major impact on life cycle costs of production of different animal species and upon their competitiveness for different types of production resources. For example, the average beef cow is capable of producing about .7 of her body weight per year in progeny market weight; comparable values are about 8 in pigs, more than 70 in meat chickens and more than 1,000 in catfish. More than 50% of the feed nutrients used by the beef cattle industry of the United States are needed to meet maintenance requirements of reproducing females. The comparable value in meat chickens is less than 3%. Further, high producing dairy cows produce five times as much milk protein per unit of feed as beef cattle produce as beef protein. Small differences in reproduction rate of beef cattle can have a major effect on costs of production and on the production resources for which beef cattle are competitive. Results from experimentation and computer simulation suggest that input costs per unit of beef output could be reduced by from 20 to 30% for the proportion of the herd that produces twins.

A twinning technology would require a highly intensive production system. Initial calculations indicate that a twinning rate of about 40% may be needed to make a twinning technology economically viable. Because of the time and effort required to develop a population with a twinning frequency of 40% or greater, private sector interests are not likely to make the investment required. Thus, the development of a population of cattle that has a high breeding value for twinning (i.e., 40% or greater) and is competitive in production and carcass traits is an essential component of a twinning technology for use by the beef cattle industry.

## Procedure

The effort was implemented as a formal project in 1981. There were 307 foundation females in the project with 96 originating in private sector herds and 211 originating from other projects at the Research Center. Twinning records of foundation cows before and after entry into the twinning project are shown in Table 1. Foundation sires have included sons of the foundation cows, and a Charolais sire and a Pinzgauer sire whose daughters produced twins at a high frequency in another project at the Research Center. Also, semen from Swedish Friesian (8 sires), Swedish Red and White (5 sires), and Norwegian Red (2 sires) whose daughters had produced twins at a frequency of from 8-13% has been imported and used in the project.

Breeds represented in the project include: (1) Holstein, (2) Simmental, (3) Charolais, (4) Brown Swiss, (5) Braunvieh, (6) Pinzgauer, (7) Gelbvieh, (8) Swedish Friesian, (9) Swedish Red and White, (10) Norwegian Red, (11) Shorthorn, (12) Hereford, and (13) Angus. The intent was to sample breeds that twin at a relatively high frequency. The Shorthorn, Hereford and Angus do not meet this criterion and were introduced as residual from grade-up programs to breeds that were introduced into the project and produce twins at a relatively high frequency.

A multiple trait (ovulation rate and twinning rate) repeated records animal model was used to predict breeding value (PBV) for twinning rate. This procedure combines information on individuals and relatives for ovulation and twinning rate and was implemented with selections and matings made in 1990.

About 750 calving cows are included in the project. Calving is both spring and fall. Mating seasons are 70 days. About one-fourth of females (heifers and cows) with highest predicted breeding value for twinning (PBV) are mated by artificial insemination (AI) to progeny proven sires for the full breeding season. These matings provide the young sires to be progeny tested. The remaining heifers are mated by natural service to young high PBV but unproved sires for the full mating season and remaining cows are mated AI to young high PBV but unproved sires for 40-42 days and cleaned up by natural service mating to young high PBV but unproved sires for 28-30 days.

Breeding assignments to young high PBV but unproved sires are made with the intent of obtaining 8-10 daughter and 8-10 son progeny conceived in both spring and fall mating seasons.

All females are examined by ultrasonography 40-80 days postconception to determine number of fetuses.

Calves are weaned at an average age of 140-150 days (late August for spring born calves and late January for fall born calves). Calves are creep fed and both sexes are fed a growing diet from weaning to an average age of 200 days.

At an average age of 200 days candidate males (about 50 per year with highest PBV) are identified and fed for 140 days on a diet of 2.69 Mcal ME/kg of dry matter and 12.88 C.P. at which time final decisions are made on bulls (about 25 per year) to be retained for progeny testing. Males not identified at an average age of 200 days to be developed out as potential sires for progeny testing are castrated and grouped by weight into three weight classes (pens) and fed a diet of high energy density (3.12 Mcal ME/kg of dry matter) from an average pen weight of 600-625 lb to a final pen weight of 1300-1325 lb. Growth and carcass data are obtained on all castrate males.

Heifers are developed on a standard breeding heifer development program. Starting at an average age of about 12 months, ovulation rate is determined by rectal palpation of corpora lutea for 8-10 estrous cycles. Heifers are mated first at an average age of about 1.6 yr. Fall born heifers are mated in spring and spring born heifers are mated in fall to produce their first calves at an average age of 2.5 yr.

Between 150 and 260 units of semen are collected and frozen on each young high PBV bull included in a progeny test. About 25 young sires are progeny tested each year. Young sires are used in progeny test matings at 1.0, 1.5, and 2.0 yr so that progeny test information on ovulation rate of daughters and growth and carcass traits of sons is available when bulls are not older than 4.5 years.

In order to control rate of inbreeding, an average of five males from the 25 progeny tested each year are mated subsequently by AI in "elite" matings to approximately 25% of females with highest PBV for twinning. This mating procedure will result in use of about 25 sires in "elite" matings in each generation. Rate of increase in inbreeding should not be greater than about .5% per generation or about 5% in 10 generations, i.e., 50 years. Also, matings of progeny

<sup>1</sup>Gregory is a research geneticist, Genetics and Breeding Research Unit, MARC; Echternkamp is a research physiologist, Reproduction Research Unit, MARC; Van Vleck is a research geneticist, Genetics and Breeding Research Unit, MARC; and Cundiff is the research leader, Genetics and Breeding Research Unit, MARC.



proven sires to "elite" (high PBV) females are made so that the contribution of a single breed will not be greater than 25-30% in any individual over the longer term. This mating plan should result in the retention of high levels of heterosis for bioeconomic traits.

## Results

Twinning rate of daughters of foundation cows averaged 11% (Table 2). Estimates of heritability of twinning rate based on use of three methods ranged from 6-9%. Analysis of records provided by the Swedish Government Artificial Insemination Organization indicated that twinning in cattle is inherited as a quantitative trait, i.e., a relatively large number of genes are likely involved, each with relatively small effects.

At the time the project was implemented it was recognized that a predictor of genetic capacity to produce twins that could be evaluated at a young age was needed in order to make significant progress in increasing twinning rate. Such a predictor is needed to reduce generation interval and because it is not possible to keep all females to evaluate their twinning rate on more than a limited number of parturitions. The most obvious predictor to investigate was ovulation rate in puberal heifers because it was believed that ovulation rate was likely the most limiting factor.

The following factors confirmed the potential value of using ovulation rate in puberal heifers as an indirect selection criterion for twinning rate.

1. As validated by laparoscopy, ovulation rate can be determined with high precision (greater than 85%) by rectal palpation of corpora lutea.
2. The effects of ovulation rate (1 or 2) on embryonic and fetal survival are small and nonsignificant.
3. Unilateral and bilateral multiple ovulations do not differ in embryonic and fetal survival.
4. Heritability of ovulation rates in individual estrous cycles of puberal heifers averaged .16 in one study. Heritability of ovulation rate was .07 for a single estrous cycle and .34 for an average of 7.9 estrous cycles in another study.
5. Estimates of genetic correlation between averages for ovulation rate in five or more estrous cycles in puberal heifers and subsequent twinning rate approached unity.
6. Thus, by observing ovulation rate in puberal heifers for ~8 estrous cycles we know as much about their genetic value for twinning as we would know after a lifetime of twinning rate observations.

*Constraints to a Twinning Technology.* The following constraints must be at least partially alleviated in order for a twinning technology to be economically viable.

1. Greater dystocia – 35% vs 23%.
2. More retained placentas – 21.5% vs 2.8%.
3. Longer postpartum interval – 77 vs 63 days.
4. Lower subsequent conception rates – 71% vs 85%.
5. More days to pregnancy – 93 vs 85 days.
6. Reduced perinatal survival – 82 vs 97%.

*Some Considerations in Alleviating Constraints.* Days to estrus, conception rate, and days to pregnancy were not affected by number of calves reared (1 vs 2) in cows birthing twins. These findings were interpreted to result from inadequate prepartum nutrition in cows birthing twins. Results from an experiment conducted at the University of California-Davis showed that cows gestating twins did not have sufficient body capacity to consume enough feed of a low energy density diet to meet their nutritive requirements

in the last trimester of gestation. Survival at birth was greater for single than for twin born calves (97% vs 82%) but twins and singles did not differ in postnatal survival. When dystocia was experienced, survival to birth was 95% for singles but only 73% for twins. When dystocia was *not* experienced, survival to birth was 99% for singles and 92% for twins. The greater difference in survival between twins and singles when dystocia was experienced than when dystocia was *not* experienced is believed to result largely from failure to provide timely assistance at parturition.

Thus, the identification of cows gestating twins to provide for their: (1) higher nutritive requirements in the last trimester of gestation, and (2) higher calving assistance requirement at parturition is needed to make twinning an economically viable production technology. Ultrasonography at 40-80 days post-conception can give high precision in identifying cows gestating twins.

A summary of the effects of age (months) on ovulation rate of puberal heifers is presented in Table 3. These results show a major effect of age to 11 months, some effect to 12 months but no effect of age between 12 and 18 months.

A summary of change in ovulation rate in puberal heifers by year of birth is presented in Table 4 for each birth year since 1984 when ovulation rate determinations were started. Large changes in ovulation rate were observed to birth year 1987 but little change was observed for birth years subsequent to 1987.

A summary of the effects of month on ovulation rate of puberal heifers is presented in Table 5. Ovulation rates were highest in June and through fall and early winter months of September through December. The months with highest ovulation rates coincide, generally, with spring (June and July) and fall (November and December) breeding seasons.

A summary of twinning rate by *year of birth* since 1981 of females born in the project is presented in Table 6. A reasonably consistent rate of increase is shown through birth year 1986. Females born in 1987, 1988 and 1989 show a much higher twinning rate than females born in prior years. Our interpretation is that this increased twinning rate is likely accounted for by the greater use of high PBV progeny proven sires and the result of consideration of ovulation rate in puberal heifers in selection decisions.

A summary of twinning rate of females born in the project by *year of calving* is presented in Table 7. A reasonably consistent rate of increase is shown through 1989 calving year. Females calving in 1990 and 1991 showed a marked increase in twinning rate relative to prior years. Again, this likely reflects the greater use of high PBV progeny proven sires and the consideration of ovulation rate in puberal heifers.

A summary of twinning rate by age of female for 1991 calving (spring and fall) is shown in Table 8. Twinning rate normally increases in second and third parturitions. For 1991 and 1992, age of dam adjustments for twinning rate to a mature basis were: 2 yr olds = 16.3% and 3 yr olds = 2.3% after adjusting records to a common predicted breeding value. The lower twinning rate of females six or more yr old indicates that the younger females had a higher genetic capacity to produce twins and suggests a high rate of genetic improvement in twinning rate.

Providing the germplasm (breeding stock) to the beef cattle industry is required for the implementation of a twinning technology. Thus, young males (two yr old) that are in the process of being progeny tested are sold at public auction with a repurchase option that will be exercised within three years for highly superior males. In addition to PBV for twin-



ning rate, growth rate of all progeny and carcass traits of castrate male progeny will be considered. Males on which the repurchase option is exercised will be licensed to an artificial insemination organization that will offer semen to the beef cattle industry.

For greater detail see:

1. Keith E. Gregory, S. E. Echternkamp, G. E. Dickerson, L. V. Cundiff, R. M. Koch, and L. D. Van Vleck. 1990. Twinning in cattle: I. Foundation animals and genetic and environmental effects on twinning rate. *J. Anim. Sci.* 68:1867-1876.
2. Sherrill E. Echternkamp, K. E. Gregory, G. E. Dickerson, L. V. Cundiff, R. M. Koch, and L. D. Van Vleck. 1990. Twinning in cattle: II. Genetic and environmental effects on ovulation rate in puberal heifers and postpartum cows and the effects of ovulation rate on embryonic survival. *J. Anim. Sci.* 68:1877-1888.

**Table 1—Foundation cows in twinning project**

	Records before entry	Records after entry
Number	307	307
Progeny	1,348	1,055
Parturitions/cow	3.0	2.9
Progeny/parturition	1.50	1.17

**Table 2—Twinning rate of daughters of foundation cows**

	All Data
No. daughters	710
No. parturitions	1,374
Parturitions/daughter	1.94
Progeny/parturition	1.11

**Table 3—Summary of ovulation rate of puberal heifers by age class**

Age months	Mean ovulation rate
≤ 11	1.06
12	1.12
14	1.16
16	1.16
≥ 18	1.17

**Table 4—Ovulation rate of puberal heifers by year of birth**

Year of birth	Mean ovulation rate
1984	1.09
1985	1.10
1986	1.11
1987	1.15
1988	1.16
1989	1.16
1990	1.14

3. Keith E. Gregory, S. E. Echternkamp, G. E. Dickerson, L. V. Cundiff, R. M. Koch and L. D. Van Vleck. 1990. Twinning in Cattle: III. Effects of twinning on dystocia, reproductive traits, calf survival, calf growth and cow productivity. *J. Anim. Sci.* 68:3133-3144.
4. L. Dale Van Vleck, K. E. Gregory and S. E. Echternkamp. 1991. Ovulation rate and twinning rate in cattle: Heritabilities and genetic correlation. *J. Anim. Sci.* 69:3213-3219.
5. L. Dale Van Vleck, K. E. Gregory and S. E. Echternkamp. 1991. Prediction of breeding values for twinning rate and ovulation rate with a multiple trait, repeated records animal model. *J. Anim. Sci.* 69:3959-3966.

**Table 5—Summary of ovulation rate of puberal heifers by month**

Month	Mean ovulation rate
January	1.14
February	1.13
March	1.11
April	1.14
May	1.12
June	1.16
July	1.14
August	1.13
September	1.16
October	1.16
November	1.16
December	1.15

**Table 6—Summary of twinning rate by year of birth (Females born in project)**

Birth year	No. parturitions	No. born/parturition
Overall mean	3,618	1.18
1981	321	1.08
1982	283	1.11
1983	507	1.10
1984	628	1.12
1985	705	1.15
1986	456	1.17
1987	394	1.29
1988	234	1.35
1989	90	1.24

**Table 7—Summary of twinning rate by year of calving  
(Females born in project)**

Calving year	No. parturitions	No. born/ parturition
Overall mean	3,618	1.10
1981	47	1.00
1982	41	1.06
1983	61	1.10
1984	109	1.06
1985	215	1.06
1986	292	1.08
1987	446	1.09
1988	435	1.11
1989	555	1.14
1990	654	1.19
1991	763	1.24

**Table 8—Summary of twinning rate for 1991 calving by  
age class (Females born in project)**

Age	No.	No. born/ parturition
Overall Mean	763	1.25
2	192	1.21
3	141	1.30
4	111	1.30
5	117	1.25
≥ 6	202	1.16